



SPACE SHUTTLE PROGRAM
Space Shuttle Projects Office (MSFC)
NASA Marshall Space Flight Center, Huntsville, Alabama



STS-112/ET-115 Flight Readiness Review

External Tank Project



September 17, 2002



Overview

Presenter J. Pilet / LMSSC-ET

Date September 17, 2002 Page 2

- **Limited Life Component Status**
 - All items within required life through scheduled launch date plus 90 days
- **Significant Changes**
 - LO₂ Tank Changes for Higher Ullage Pressures
 - Intertank Access Door Changes
 - ET Shuttle Observation Camera
 - *Presented with Program Integration*
- **Processing Anomalies**
 - LH₂ Tank Aft Dome Damage
 - Repair of LO₂ Feedline Insulation
- **Readiness Statement**



LO₂ Tank Changes to Accommodate Higher Ullage Pressures

Presenter J. Pilet / LMSSC-ET

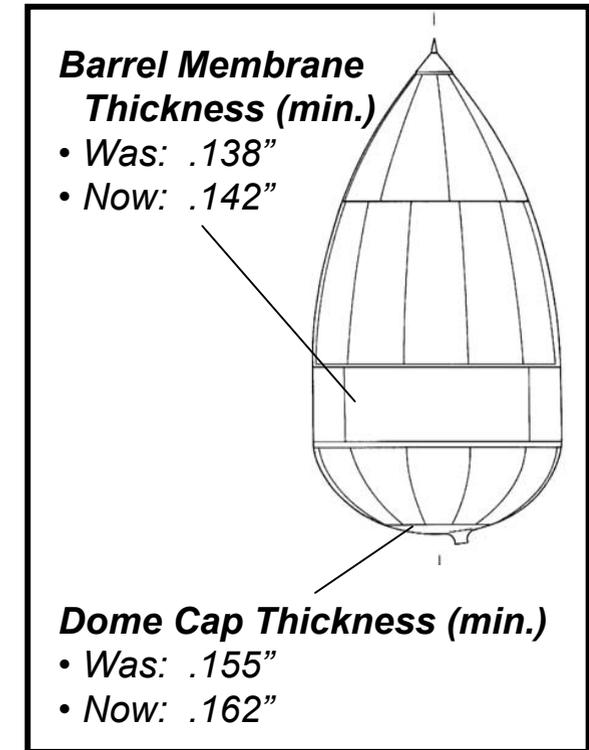
Date September 17, 2002 Page 3

• Change

- Increased LO₂ tank barrel and dome cap pressure critical wall thicknesses
 - Thickness increase required to accommodate expansion of ullage pressure ICD requirement during late High-Q
- Increase in pressure requested to provide the Orbiter fleet the capability of using any combination of spare GO₂ fixed orifice flow control valves
 - 0.58 psig maximum increase in pressure occurs at t = 78 secs. for nominal mission
 - Ullage Pressure @ 78.0 secs. = 27.4 psia
- Pressure increase also required minor revisions to LO₂ tank proof test pressures and post-proof NDE requirements

• Basis for Certification

- LO₂ tank membrane thickness changes are certified by similarity, proof test, and analysis
 - Basic geometry and material of hardware is unchanged
 - Proof test demonstrates a minimum of 112% of design limit load for critical location
 - Stress analysis shows adequate Factor of Safety for resized hardware
 - Min FS = 1.28 (FS req'd = 1.27) Barrel Wall Ultimate Tension





Redesigned Intertank Access Door

Presenter J. Pilet / LMSSC-ET

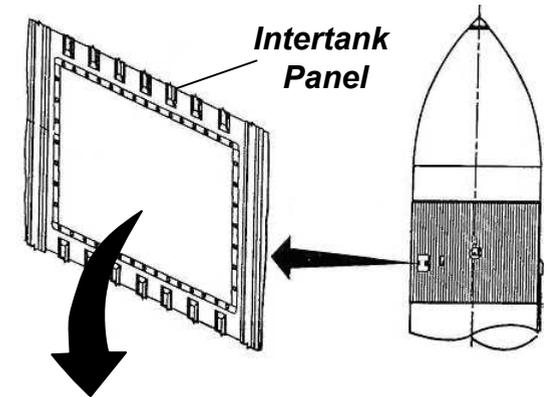
Date September 17, 2002 Page 4

• Change

- Redesigned composite Intertank Access Door to implement a new material system
 - Replaced PMR-15 with AS4/3501-6 Graphite/ Epoxy composite material system
 - Commonly used material system with well-documented material property database
 - Much easier to process, but has lower strength at elevated temperatures
 - Configuration optimized by tailoring ply thicknesses to minimize weight impacts and improve design capability

• Basis for Certification

- Design is certified by test and analysis
 - Structural and aero-thermal testing performed to verify the design
 - Structural testing demonstrated 342% of critical design limit load condition
 - Post-test ultrasonic NDE and cut-up examination showed no indications of delamination or imminent failure
 - Stress analysis shows adequate Factor of Safety for the redesigned door
 - Min FS = 1.57 (FS req'd = 1.40) Ply Tension





LH₂ Tank Aft Dome Damage

Presenter J. Pilet / LMSSC-ET

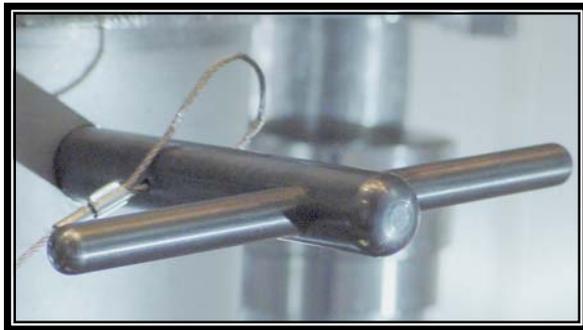
Date September 17, 2002 Page 5

- **Issue**

- LH₂ tank aft dome membrane damaged during preparations for post-proof tank cleaning

- **Background**

- During assembly of the wash probe, the tether on one of the disconnect pins failed resulting in the pin dropping the full length of the tank and impacting the aft dome
- Wash probe is a two part assembly joined by two disconnect pins (16.5" long x 5/8" dia.; 2.2 lbs)



Disconnect Pin with Tether



Failed Tether

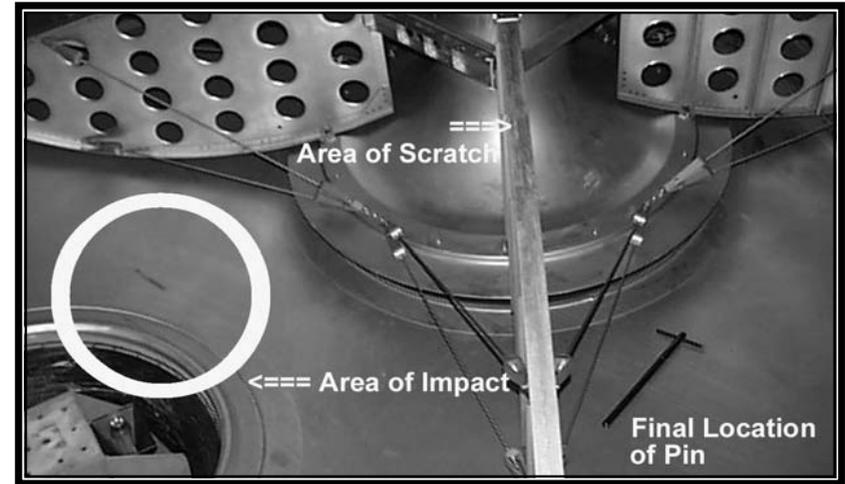
LH₂ Tank Aft Dome Damage

Presenter J. Pilet / LMSSC-ET

Date September 17, 2002 Page 6

• Damage Assessment

- Detailed internal inspection showed that damage was isolated to the aft dome cap and anti-vortex baffle
 - Total of 13 impact sites identified with 6 having indentations or raised metal and 2 having slight OSL protrusions (.007" maximum offset)



• Rationale for Acceptance

- Primary damage occurred in thicker areas of the dome cap
 - All visible damage was blended and sanded smooth
- Penetrant and radiographic inspection revealed no external or internal defects
 - Fracture analysis of hypothetical flaws, equal to the penetrant detectability limit in length, shows mission life greater than 400
- Stress Analysis shows a Factor of Safety of 2.04 (FS req'd = 1.26) for Ultimate Tension and Bending



LO₂ Feedline Foam Repair

Presenter J. Pilet / LMSSC-ET

Date September 17, 2002 Page 7

• Issue

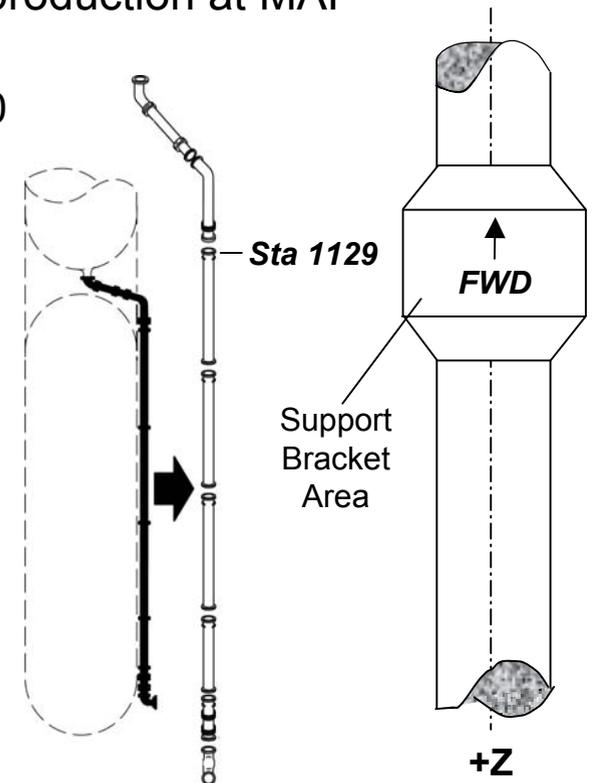
- Repair performed on LO₂ feedline foam insulation (BX-250) at Sta. 1129
 - Repair required based on foam insulation bond-adhesion (plug-pull) test evaluation

• Background

- All LO₂ feedlines using BX-250 material required plug-pull test evaluation based on investigation results of debonded material identified during production at MAF
 - Cause was isolated to unique production processing of the support bracket regions of LO₂ feedline sections with BX-250

• Actions Taken

- Performed plug-pulls on ET-115 feedline sections
 - Plug pulls at 3 of 4 stations were acceptable
 - Lowest value of 33.7 psi (35 psi required) accepted based on analytical assessment and past flight performance
 - Lower strengths previously accepted (12.7 psi min) and flown for locations on ET-112 and ET-113 with no issues
 - Plug-pulls at Sta. 1129 indicated a foam debond and required repair



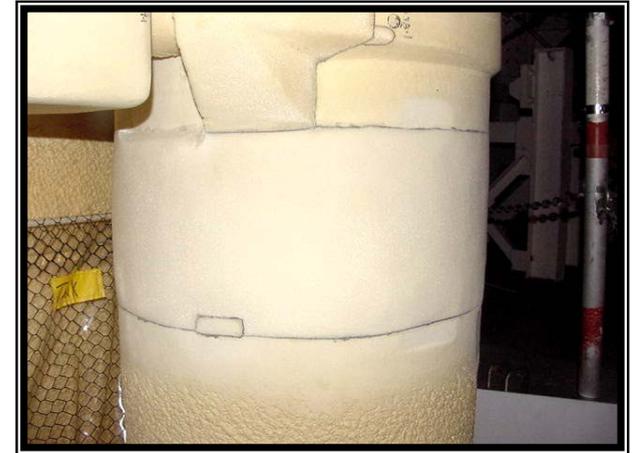
LO₂ Feedline Foam Repair

Presenter J. Pilet / LMSSC-ET

Date September 17, 2002 Page 8

• Rationale for Acceptance

- Repaired Sta. 1129 with a certified material (PDL-1034) and a validated repair procedure
 - Validation included four PDL pours at MAF using simulated geometry and orientation to represent logistics of tank at KSC
 - Performed cryogenic and room temperature plug pulls to verify application integrity
- Thermal and stress analysis performed to verify PDL performance in this application
 - Stress analysis shows FS >> 2.0 for foam loss
 - PDL provides adequate thermal protection for the substrate material
 - No change to substrate temperature or rupture altitude requirements



Repair size 8.6" long x 360°





Readiness Statement	Presenter J. Pilet / LMSSC-ET
	Date September 17, 2002 Page 9

The External Tank, ET-115, is certified and ready for STS-112 flight pending completion/closure of open and planned work